PHASE MEASUREMENTS ON THE ZGS 50 MEV LINAC

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Summary

Measurements of the radio-frequency phase at several points in the Argonne 50 MeV linac have been made, with and without proton beam, in an attempt to define the maximum phase changes and phase-shift rates that must be expected in the NAL 200 MeV linac. The initial results suggest that at the high-energy end of the tank a 22 mA beam produces a maximum phase shift of the order of 8° with a slope of at least 0.16 degree per microsecond. The magnitude and speed of the phase shift are both smaller as one goes farther toward the main drive loop. These results are only preliminary, as a better understanding of the effects of the rf amplitude control servo may show that it is modifying the phase performance of the system.

1. The measurements reported in this note were made in an effort to observe the effect of beam loading on rf phase.

2. Phase measurements were made at three different loops, number 42, number 50, and number 63. Number 42 is not far from the main drive loop, number 63 is nearly at the high-energy end of the tank, and number 50 is at an intermediate position.

3. The reference signal was taken from the forward directional coupler in the output of the 4CX250B stage of the driver system. There are two amplifier stages following this point before the linac cavity, so that the phase of the reference signal should not be much affected by such variables as the final plate modulator voltage, tank buildup, etc.

4. The phase detector used was a Hewlett-Packard 10514A double balanced mixer. Its performance as a phase detector was checked at the same signal levels used in the actual measurements (about 0.4-0.43 volt dc output from a detector using a 1N416B

diode and 1000 ohm load; perhaps 0.5 to 1.0 volt rms actual rf voltage) using General Radio line stretchers to produce the known phase changes. In the vicinity of zero output voltage, its sensitivity was found to be about 5.6 millivolts per degree of phase change at 200 MHz.

5. Oscilloscope photographs were taken showing the output of the phase detector vs. time for each loop, with and without beam. Direct comparisons, by making multiple exposures on a single photograph, could not be made because there proved to be between 3 and 4 degrees of phase jitter in the system. The phase jitter was not studied in detail, but casual observation suggested that it was roughly sinusoidal at a very low rate (perhaps one cycle for 10 or 20 machine pulses.)

6. In every case, the phase in the absence of beam showed substantial oscillations (order of 6 degrees peak-to-peak) at a rate of about 33 KHz during the turn-on transient, followed by a phase droop at the rate of one degree in 25 or 30 microseconds. It was not possible to identify the causes of these effects.

7. When beam was turned on, the phase oscillations damped out more rapidly, and the mean phase was displaced. Figure 1 and Figure 2 show selected portions of the phase waveforms observed at loop 42 and loop 63, respectively. (Insufficient data were obtained from loop 50.) The first 260 microseconds of the waveforms are not shown. In the interval from 260 microseconds to 420 microseconds, 22 milliamperes of proton beam are being accelerated.

8. Figure 3 and Figure 4 show what one obtains by subtracting the "no beam" waveform from the "beam" waveform in each case. There is a substantial scatter of the data points, but it seems reasonable to approximate the results as shown, by exponential waveforms. At loop 42, the time constant is something like 50 microseconds, while at loop 63 it is appreciably faster; perhaps 35 microseconds.

9. Considerable care should be used in interpreting these preliminary results. Not enough is known at this time about the action of the amplitude servo, for example, to permit firm conclusions to be drawn.

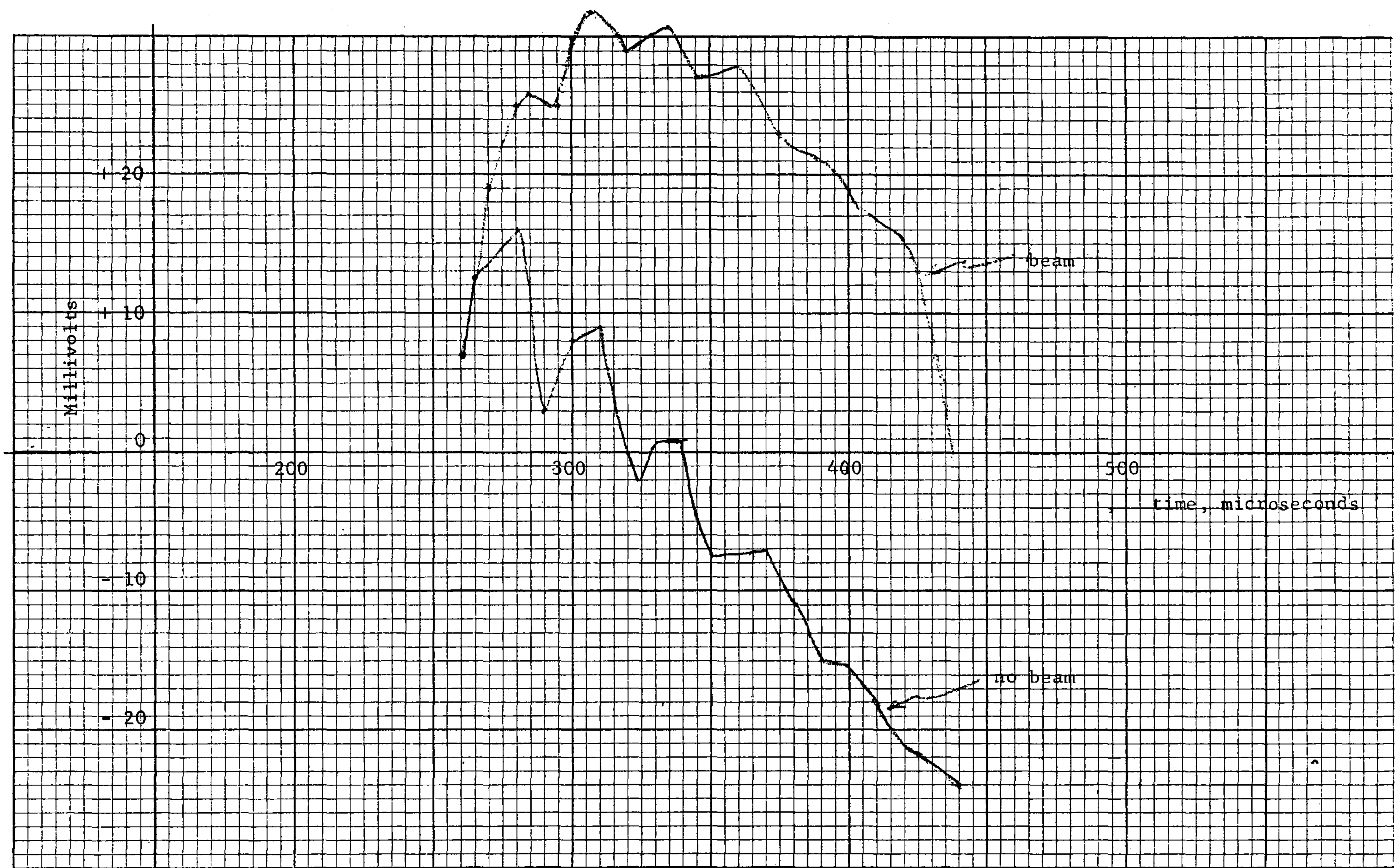

FIGURE 1. Phase signals from Loop 42

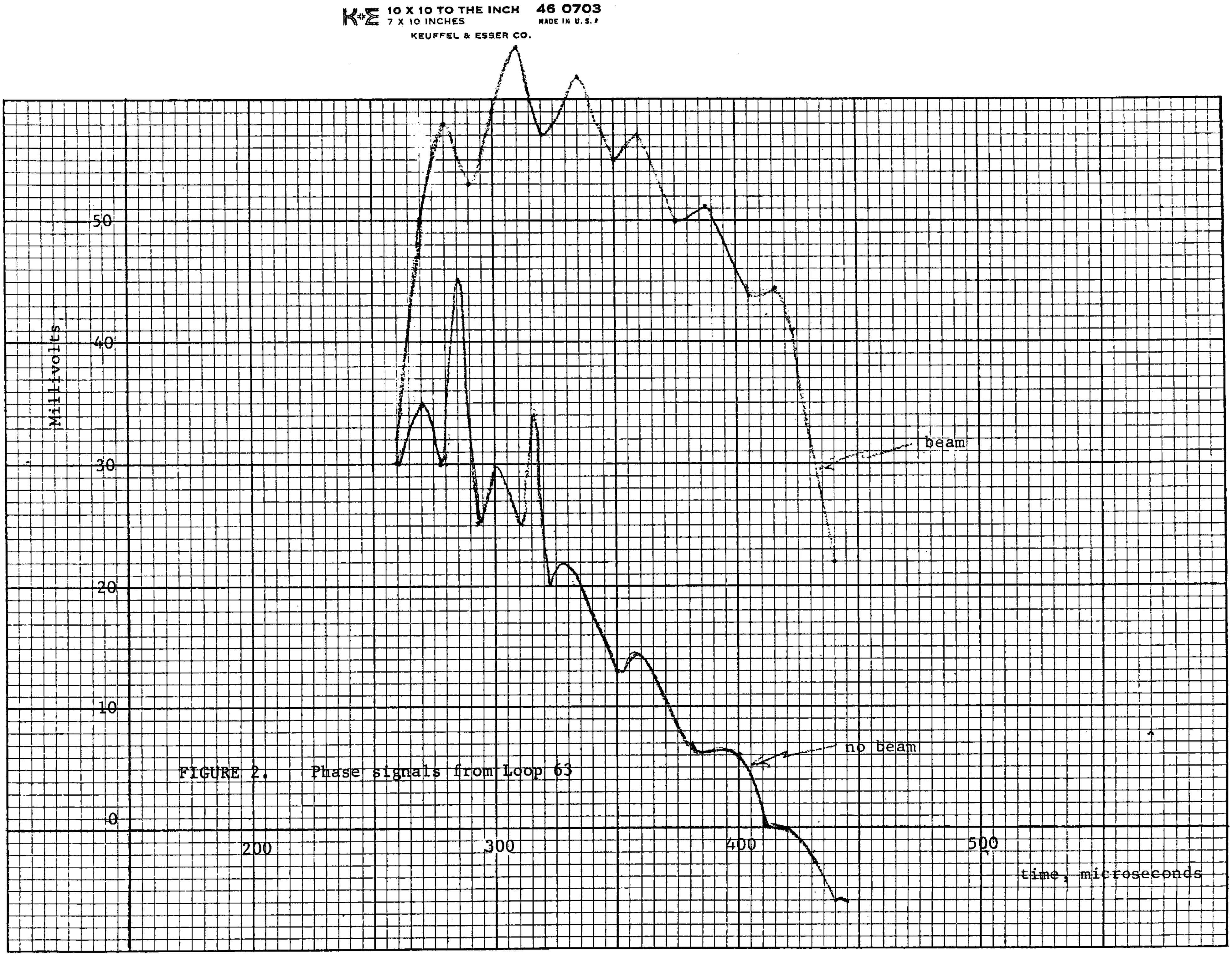

FIGURE 2. Phase signals from Loop 63

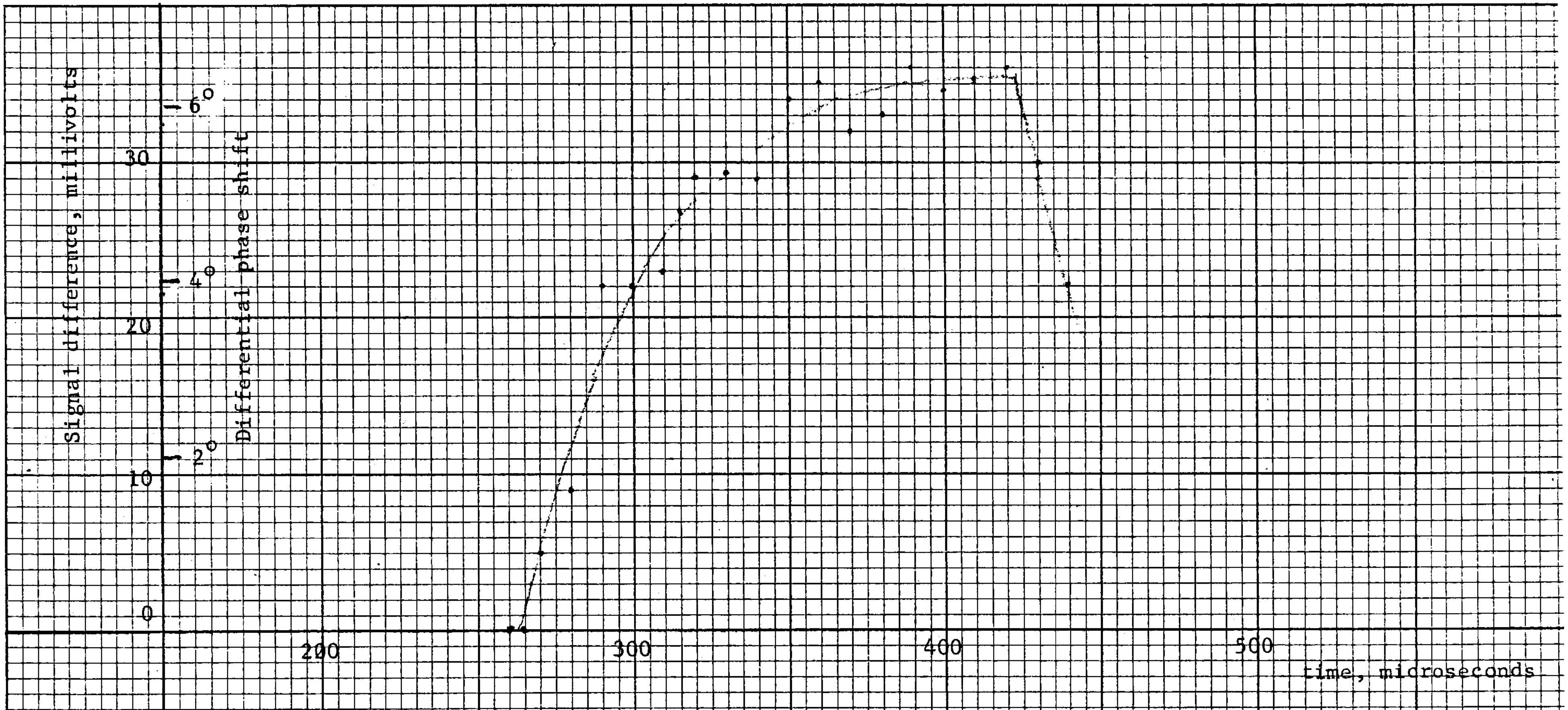

FIGURE 3. The effect of 22 ma. beam loading, as seen at loop 42

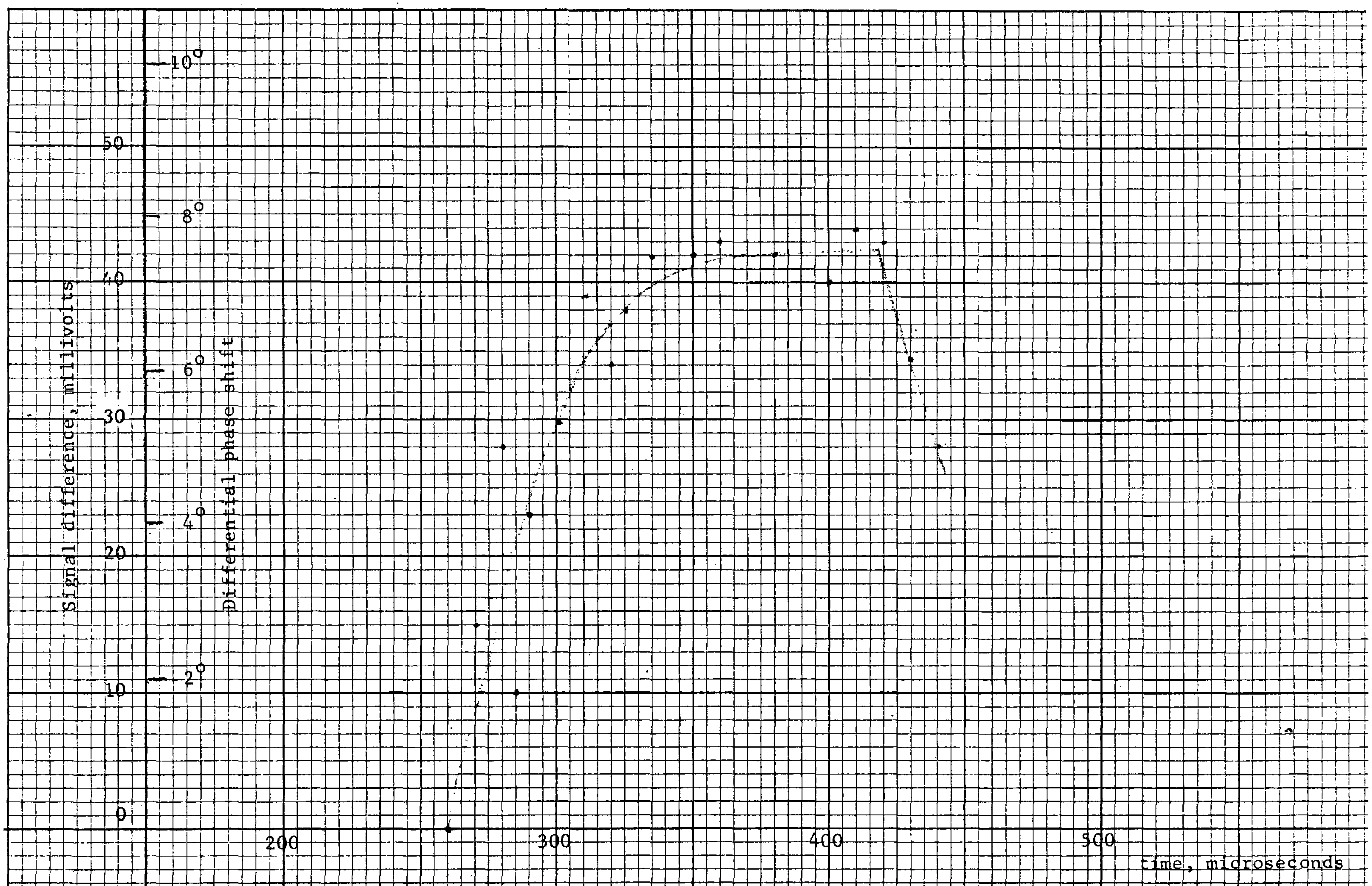

FIGURE 4. The effect of 22 ma. beam loading, as seen at loop 63